ATLAS UK-IT ITk Integration Meeting

PP1 - Mechanical Design and Data Cable Feedthroughs

INFN-LNF

D. Orecchini, F. Rosatelli, S. Tomassini

March 17th, 2020

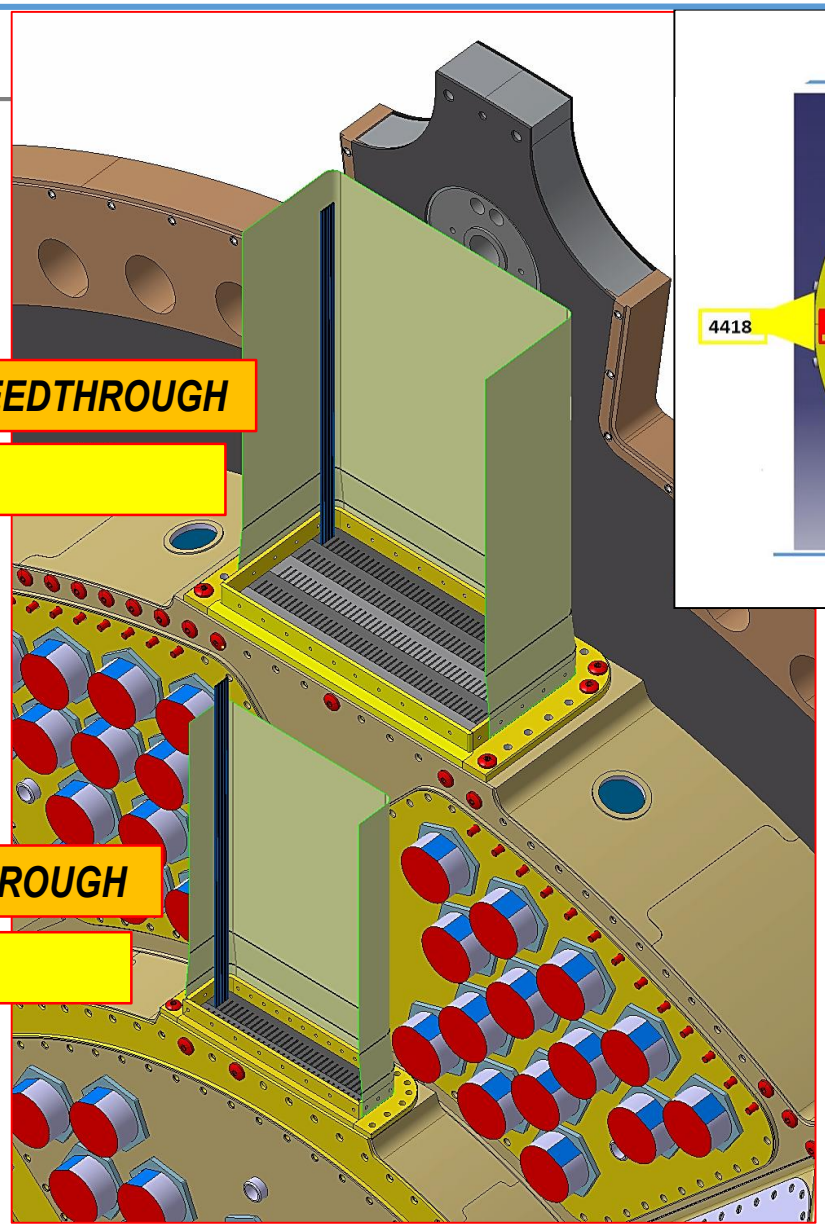
PP1-DATACABLE FEEDTHROUGH 1/2

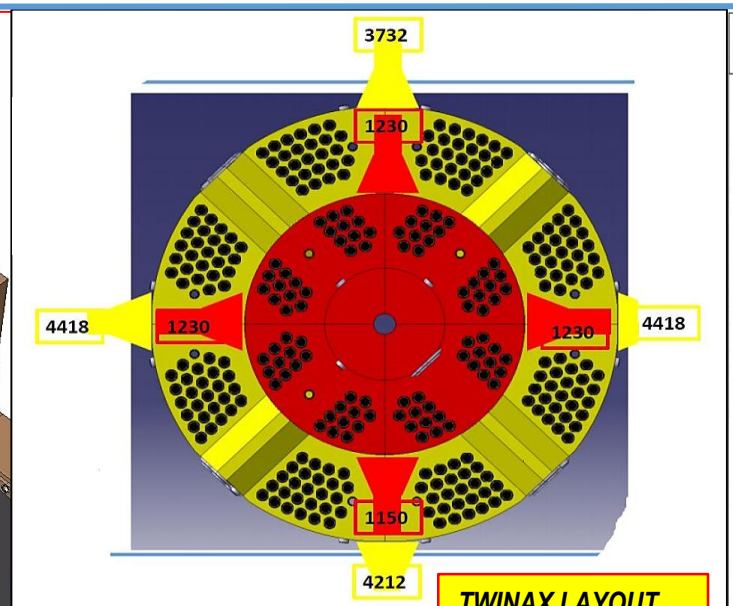
OUTER SYSTEM FEEDTHROUGH

MAX 4640 TWINAX

INNER SYSTEM FEEDTHROUGH

MAX 1260 TWINAX

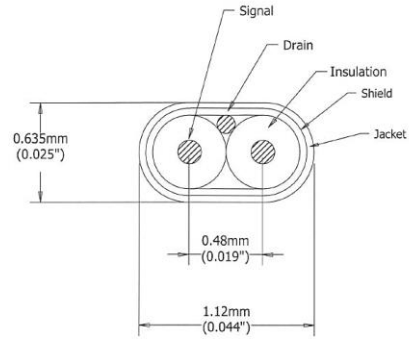




TWINAX LAYOUT
(INFO BY MATTIAS)

TEMP-FLEX a molex company

TITLE	PART No.	REV	PAGE
34 AWG, 100 Ohm Twinax	100068-0052	A	1 of 1



AWG 34

NOTES

Conductor: 34 AWG Bare Copper

Insulation: LDPE, 0.5mm (0.020") Diameter

Foil Shield: Aluminum/Polyester Tape Wrap

Drain Wire: 36 AWG Bare Copper

Jacket: Fusible Polyester

Impedance: 100+/-10 ohms

Capacitance: 50 pF/m (15.3 pF/ft) Ref.

Propagation Delay: 5.0 ns/m (1.53 ns/ft) Ref.

Skew: 16 ps/m (<5 ps/ft) @ 50% rising edge Ref.

Weight: 1.1 kg/km (0.72 lb/kft)

RoHS COMPLIANT

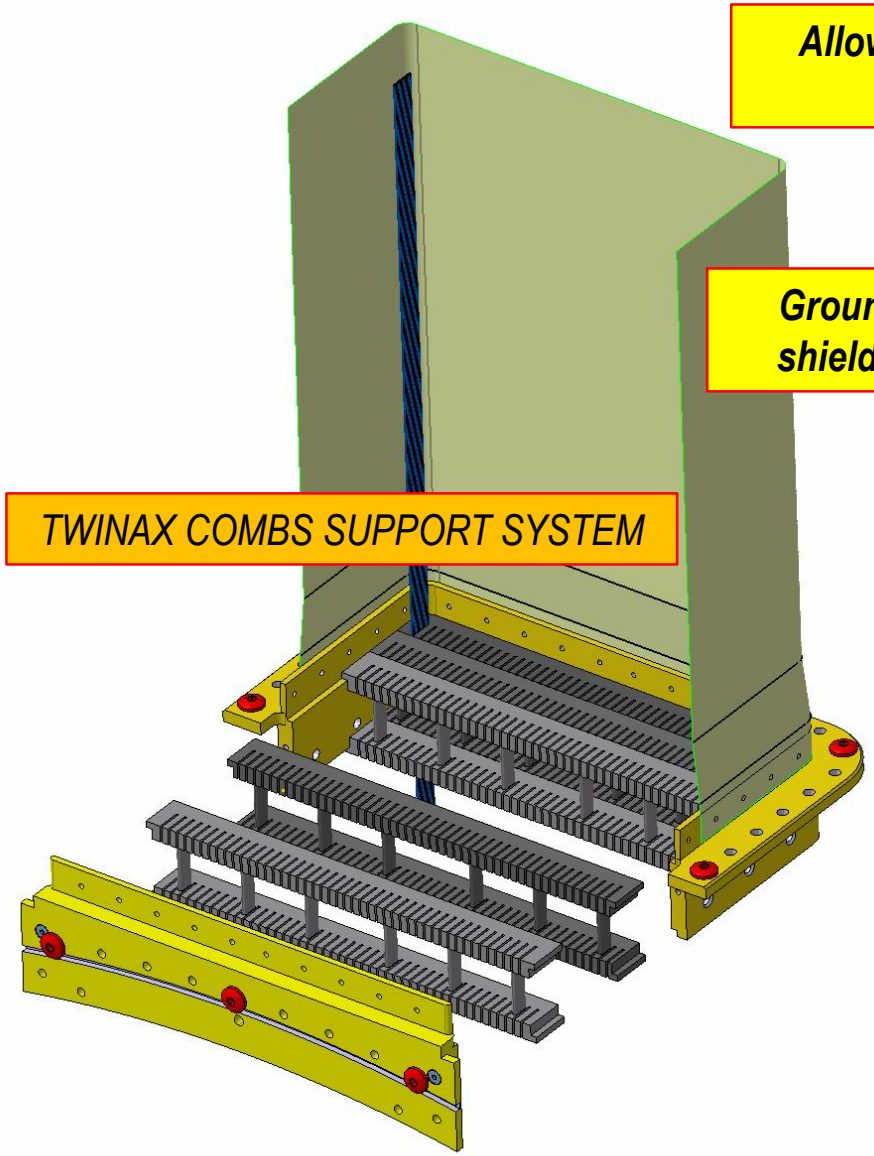
Rev	DCR	Description	App'd	Date
A	4163	Preliminary Release.	KP	1/8/15

Address: 26 Milford Road, South Grafton, MA 01560 Phone: (508)-839-5987 Fax: (508)-839-4128

DATA CABLE ADOPTED AND MAIN PARAMETERS

MORE THAN 20K LINKS TO MANAGE

PP1-DATACABLE FEEDTHROUGH 2/2

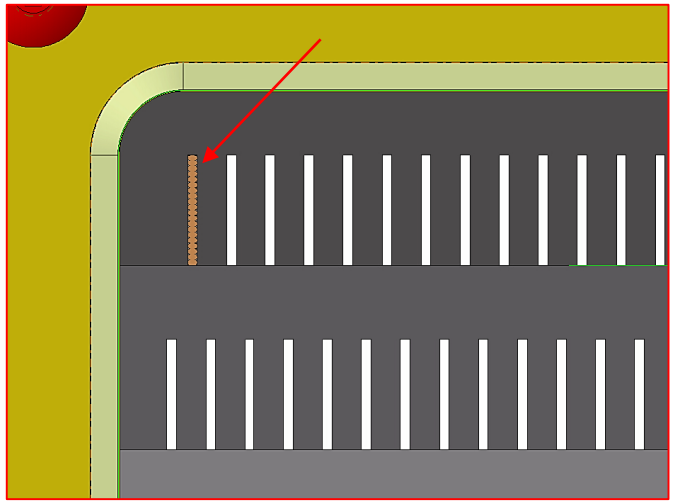


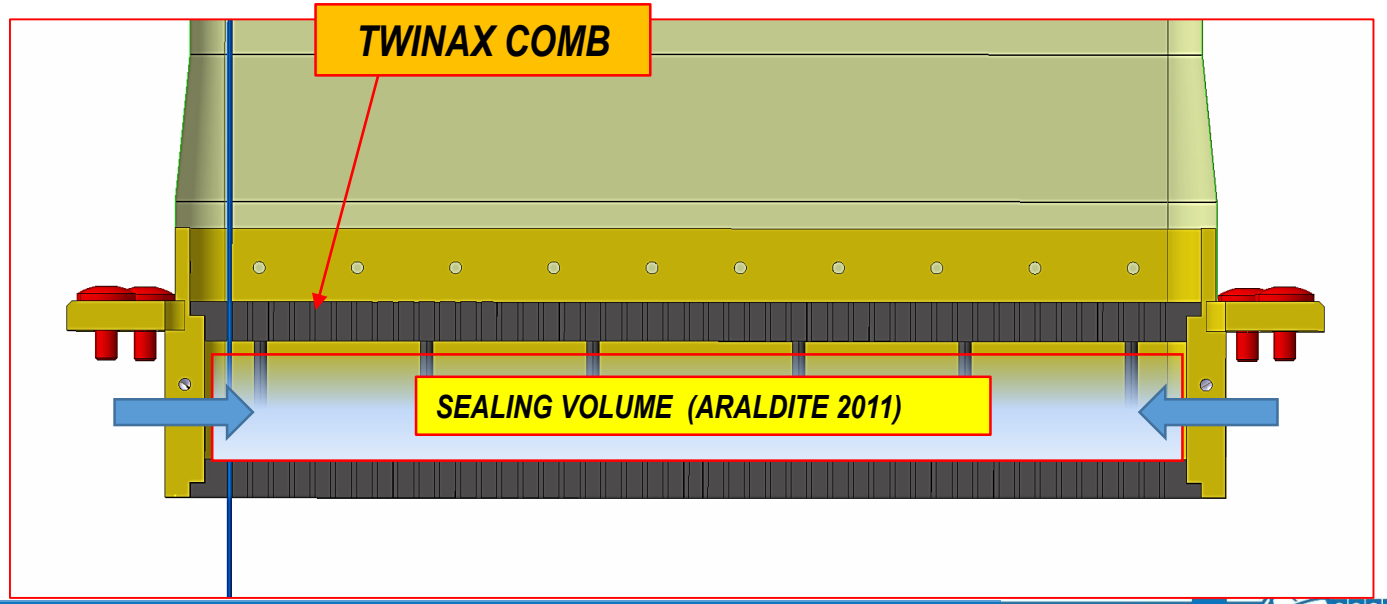
TWINAX COMBS SUPPORT SYSTEM

Grounding and shielding mesh

Allows to manage group of twinax separately

20 TWINAX per SLOT



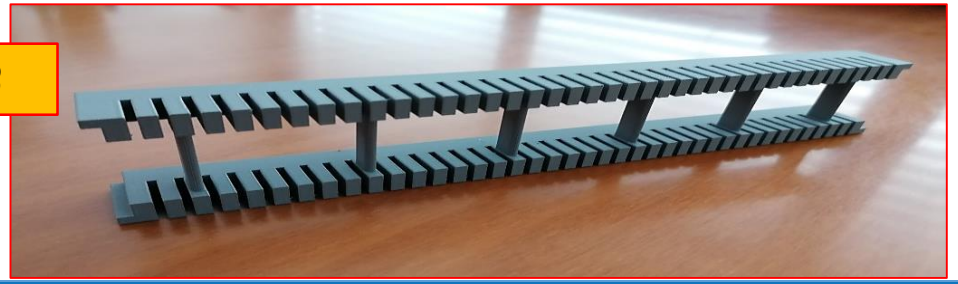


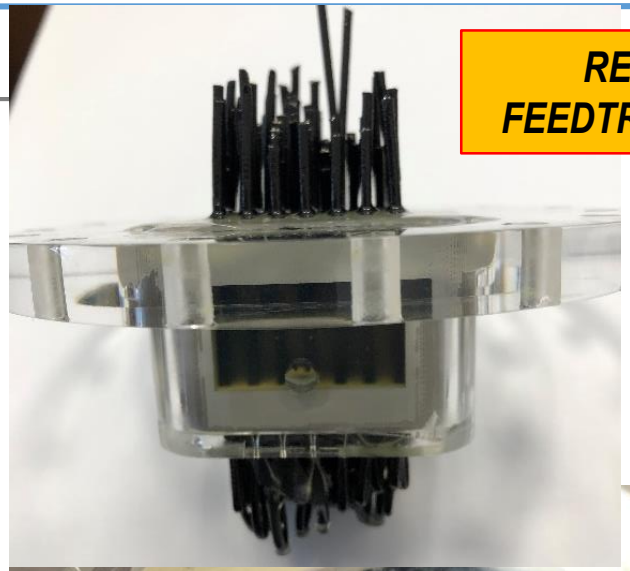
DATACABLE FEEDTHROUGH MOCKUPs

REAL SCALE DATACABLE FEEDTRHOUGH MOCKUP

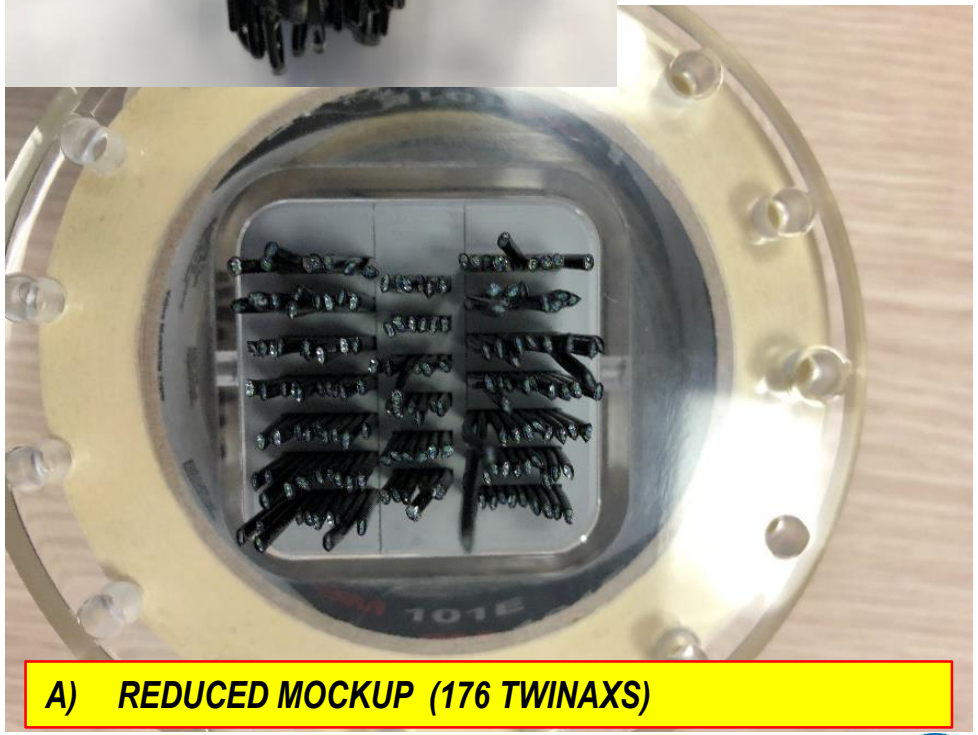
A) FULL SCALE MOCKUP TO CHECK THE TWINAX STACKING
B) ACRYLIC MADE TO CHECK THE FILLING PROCESS

COMB





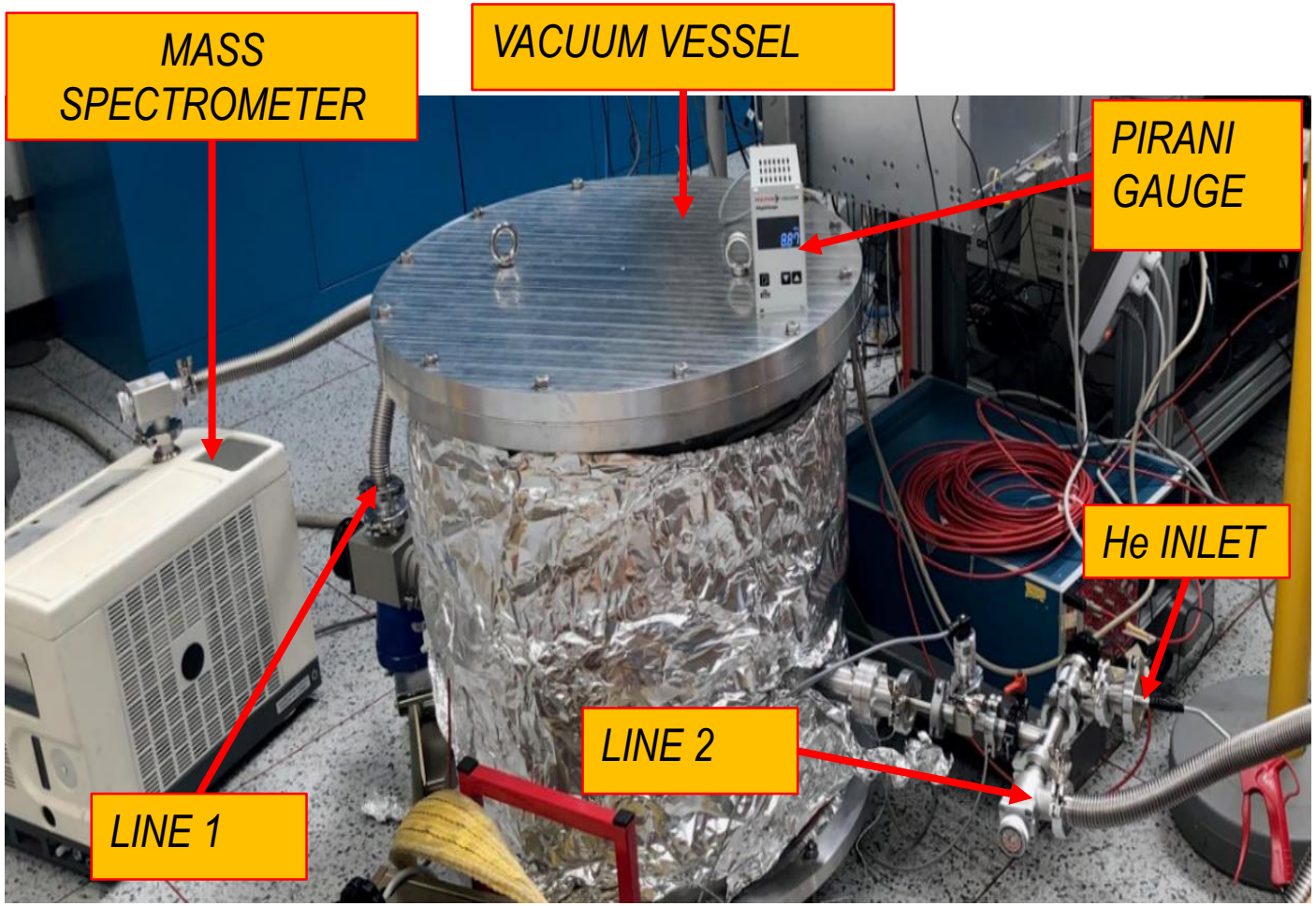
REDUCED DATACABLE FEEDTRHOUGH FOR LEAK TEST

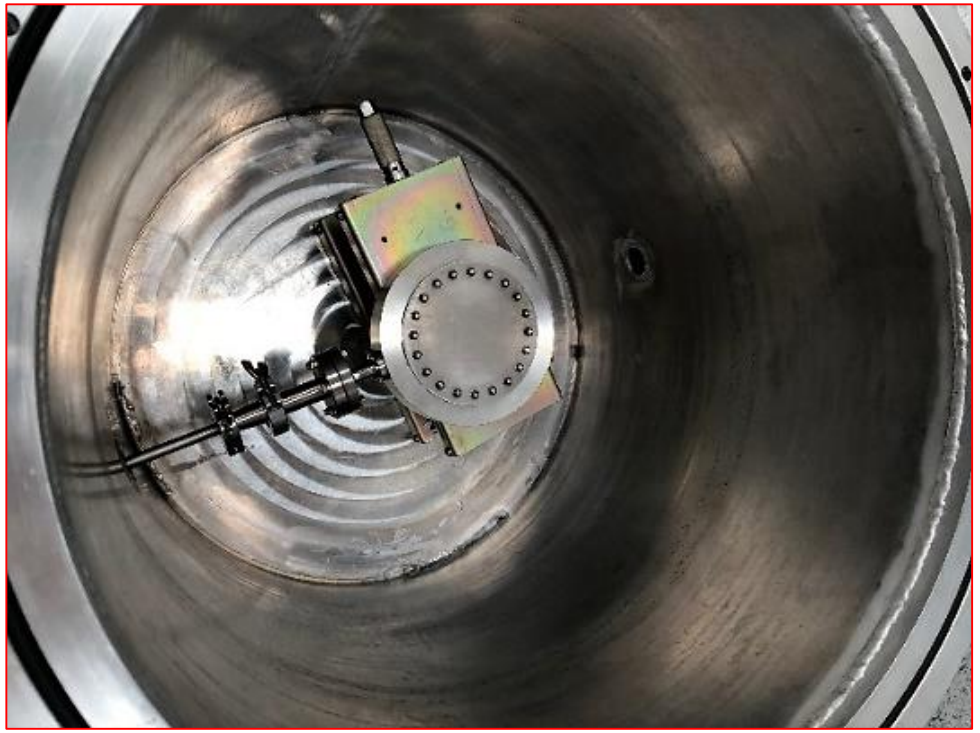


A) REDUCED MOCKUP (176 TWINAXS)

LEAK TEST SETUP

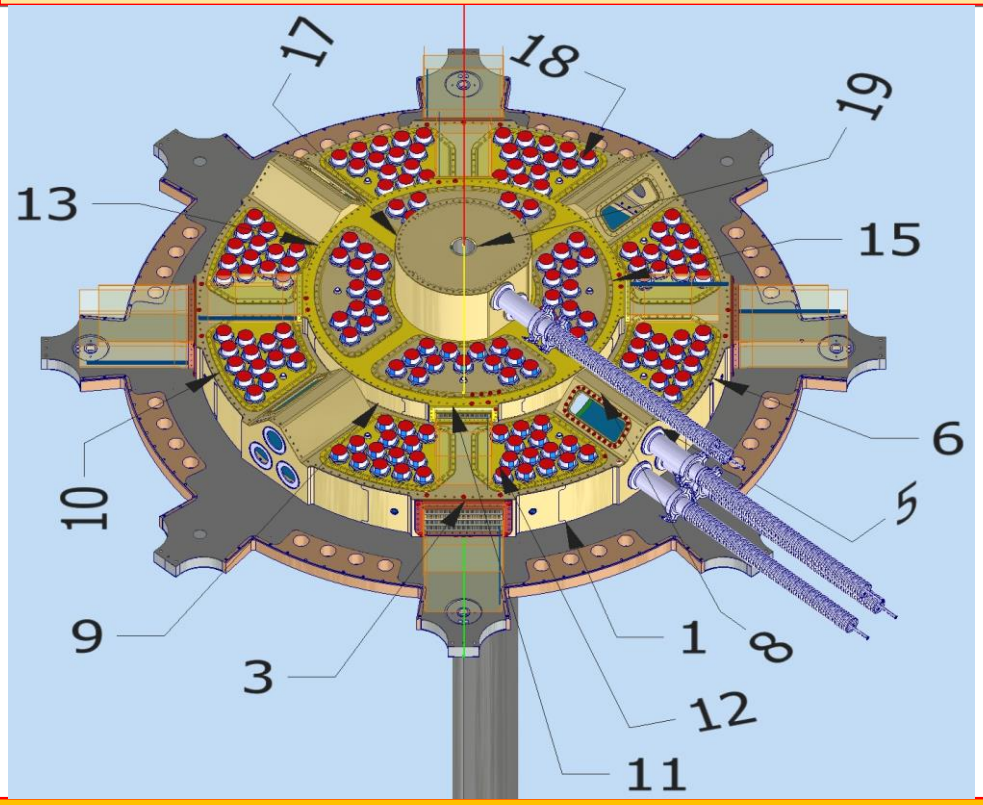
USED TO TEST THE FLANGED JOINT & THE DATACABLE PENETRATION.

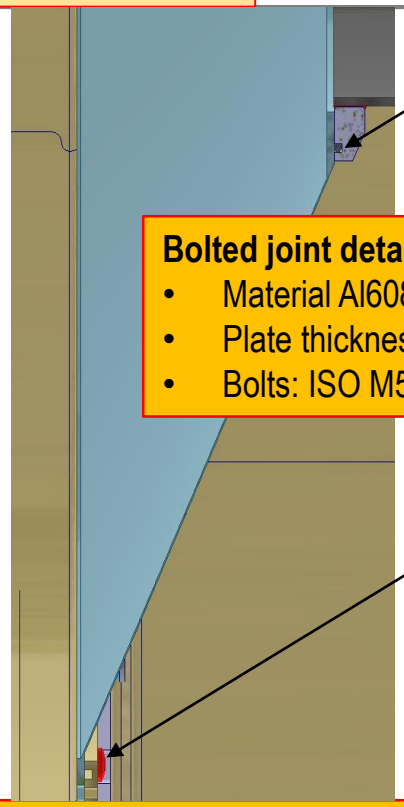


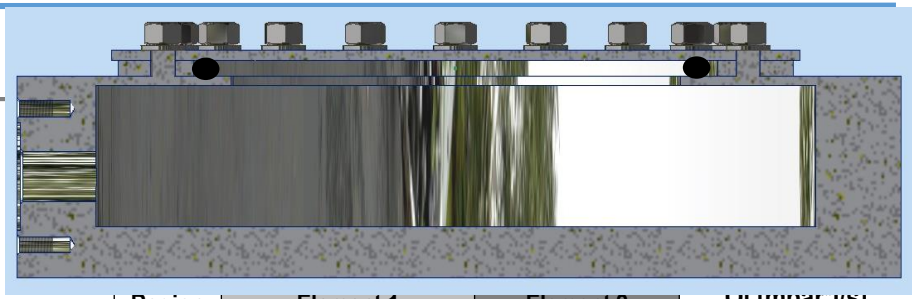


LEAK TEST OF FLANGED JOINTS (O-RING)

FPM O-RING SECT. 3,53 mm; Di 110,7 mm







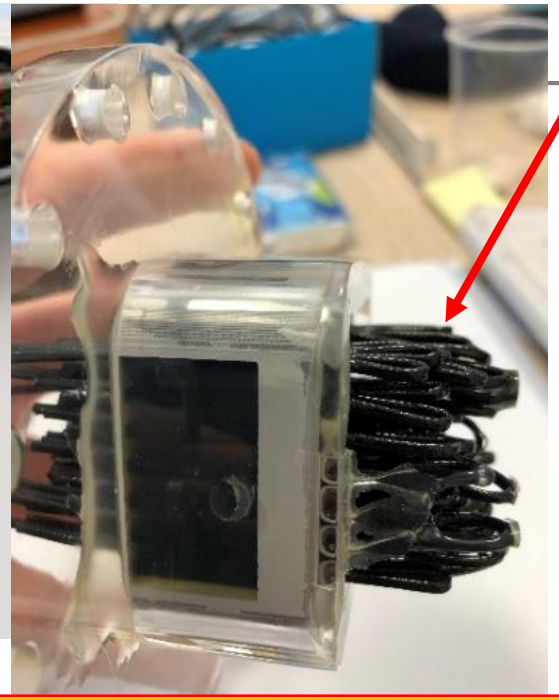
Bolted joint details:

- Material Al6082 (Anticorodal)
- Plate thickness 2 mm
- Bolts: ISO M5 - pitch 20 mm

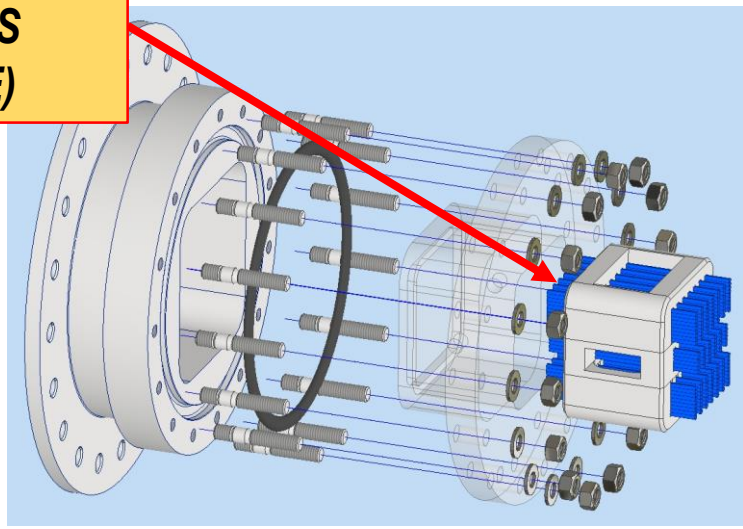
Region	Element 1	Element 2	QI [mbar l/s]
Outer			
1	Bulk head	Flange	1,52E-07
3	Flange	Data Cable	6,21E-08
5	Flange	CO2	TBM
6	Outer Flange	Intermediate Flange	1,51E-07
Intermediate			
8	Flange_base	Blank Flange	1,33E-07
9	Flange_base	Flange_Cylinder	4,16E-08
10	Flange	ACT_panel	2,69E-07
11	Flange	Data Cable	2,64E-08
12	ACT_Flange	ACT_Connectors	5,83E-07
13	Intermediate Flange	Inner Flange	8,72E-08
Inner			
15	Flange	ACT_panel	2,52E-07
17	Inner Flange	End plate	3,71E-08
18	ACT_Flange	ACT_Connectors	2,71E-07
End			
19	End plate_bore	Beam Pipe	4,30E-05
Cone			
20	Intermediate Flange	Cone	8,28E-08
21	Cone	IST	3,51E-08

- **LEAK RATE O-R** $L_{test} = 1.3 \cdot 10^{-8} mbar \cdot \frac{l}{s}\ He\ std.$
- **LEAK RATE PER UNIT LENGTH** $L_{ru} = 3.53 \cdot 10^{-10}\ mbar \cdot l/(s \cdot cm)\ He\ std.$
- **TOTAL LEAK** $L_{TOT} = 2.18 \cdot 10^{-6} mbar \cdot l/s\ He\ std$

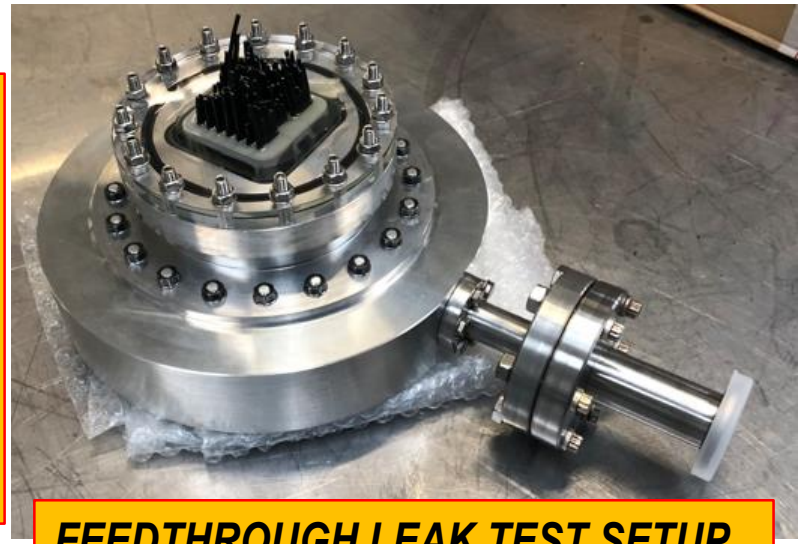
LEAK TEST OF DATACABLE PENETRATIONs



U-BEND OF CABLES (INSIDE)



- ARALDITE 2011 TO FILL THE SEALING VOLUME.
- 176 TWINAXS IN THE MOCKUP WERE USED
- LEAK RATE (MEASURED) $L_{FT} = 2.80 \cdot 10^{-5} mbar \cdot \frac{l}{s} He\ std$
- LEAK PER UNIT AREA $L_A = 1.32 \cdot 10^{-2}\ mbar \cdot l/s/m^2$
- $L_{BIG} = 2.3 \cdot 10^{-4} mbar \cdot \frac{l}{s} He\ std$
- $L_{SMALL} = 5.16 \cdot 10^{-5} mbar \cdot \frac{l}{s} He\ std$



FEEDTHROUGH LEAK TEST SETUP

LEAK TEST RESULTS

ACCORDING TO THE LEAK RATE MEASURED OF THE DIFFERENT JOINTS, THE TOTAL LEAK EXTIMATED FOR THE WHOLE PP1:

THE TOTAL LEAK FOR ONE COMPLETE PP1:

- **O-RING FLANGEs + DATACABLE PENETRATIONs**

$$L_{TOT} = 1.13 \cdot 10^{-3} mbar \cdot \frac{l}{s} \ (He\ std)$$

THIS VALUE IS MUCH LESS THAN THE SPEC Value: $312\ mbar \cdot \frac{l}{s}\ He\ std$

(FOR DETAILS SEE EDMS REPORT AT2-IP-ES-0008).

RADIATION HARD SEALING RUBBER SAMPLES

- ***AN IRRADIATION TEST AT 350 Mrad at CERN HAS BEEN PLANNED.***
- ***N. 10 DOGBONE SAMPLES AND N. 10 O-RING, BOTH IN EPDM SHIELDSEAL 663 (by James Walker) HAVE BEEN BOUGHT AND WE ARE WAITING FOR THE DELIVERY.***

https://twiki.cern.ch/twiki/bin/viewauth/Atlas/RadiationBackgroundSimulationsStep3X

FROM JAMES WALKER (Elastomer for nuclear application)
Shiedseal 663 Peroxide cured ethilene-propylene termoplymer (EPDM Family)

James Walker

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Materials Technology
Elastomers - Nuclear

160 MRad Tested

Third-party testing by AMEC

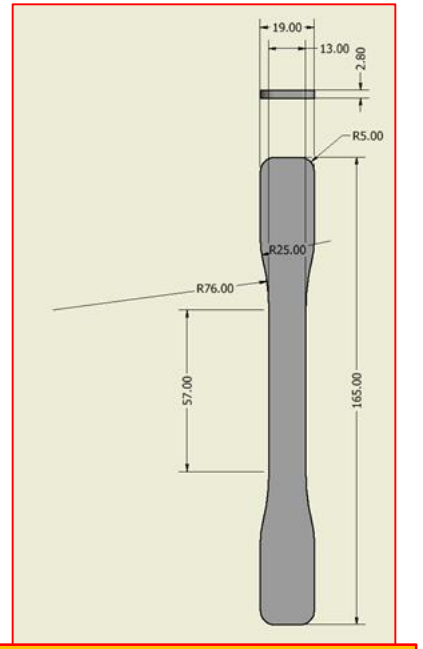
Samples of initially un-aged and thermally pre-aged Shieldseal 663 from two different batches were irradiated at a dose rate of 1 kGy.h-1 up to 1000 kGy in a Co-60 irradiation facility. A number of samples were also irradiated at 70°C to assess synergistic effects.

Samples were then exposed to a further 600 kGy, at room temperature, to simulate additional radiation from a Design Basis Event (DBE) such as a loss of coolant accident (LOCA).

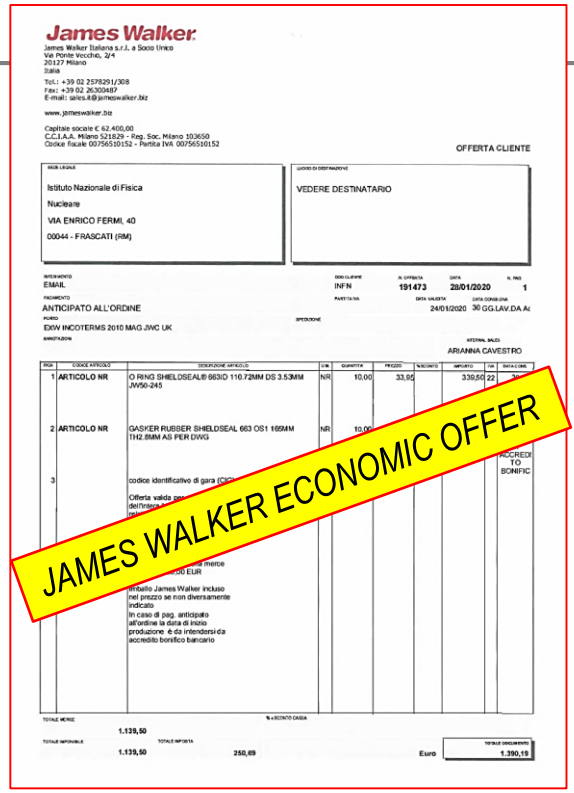
Shieldseal 663 - Radiation grade
PMUC approved material for use in French nuclear plant

- Peroxide cured ethylene-propylene terpolymer
- Strong resistance to short-term high pressure and temperature spikes
- Nominal 80 IRHD for general sealing applications

More Info



DOGBONE SAMPLE SHIELDSEAL 663

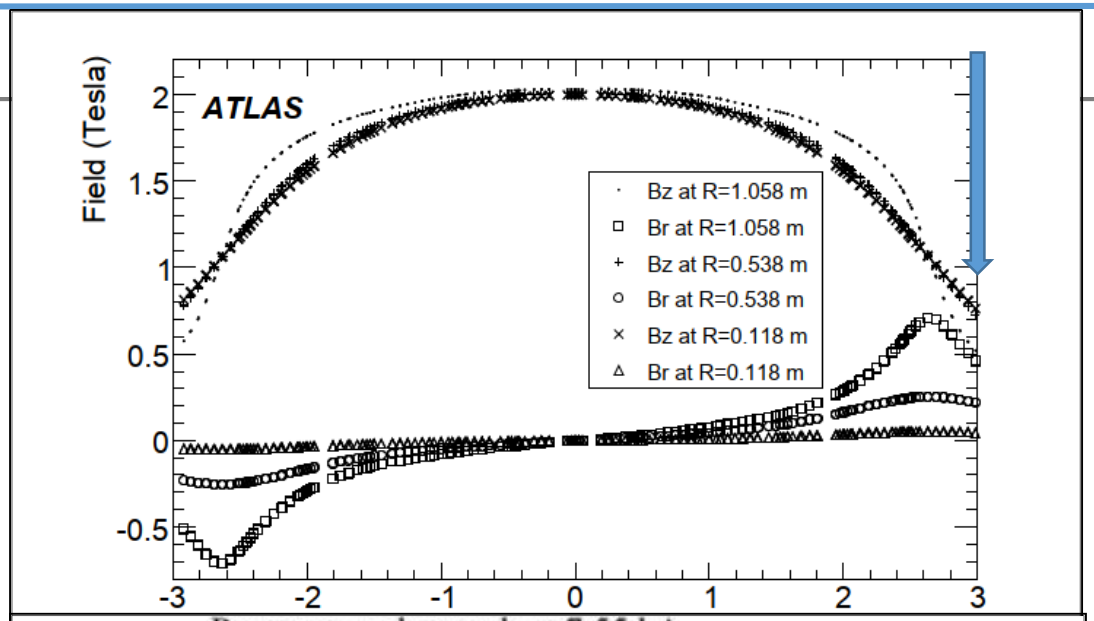


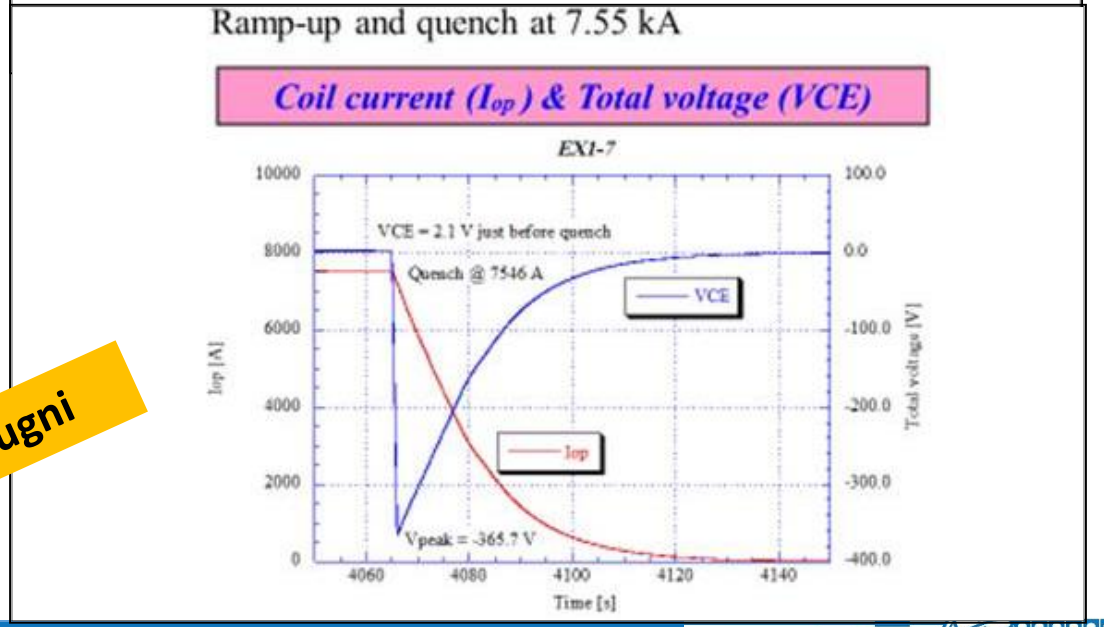
ORING SHIELDSEAL 663

SOLENOID QUENCHING

- The solenoid on the cryostat bore is superconductive @ 2T.
- The map of the B-field is available and it gives Bz and Br vs three different radii
- When the magnet quenches a current is induced in any coil that sees a dB/dt with a no-zero cross section.

- This is a generic issues for all the components inside the detector. However, at PP1, it is really relevant:
  - dB/dt (as estimated from the plot above) is high: **1T in 10sec ➔ 0.1 T/s**
  - **PP1 is a low-resistance coil-like structure**
  - **B-field** has a relevant **radial component (~ 0.7 T)** that can induce an axial force during the quenching. This would tend to 'extract" the ITK detector
  - The **Z-component of the B-field** induces a radial buckling force on PP1 cage, indeed





From Danilo Giugni

EDDY CURRENT & FORCES

surface outer (m^2)	0,9851744
B Flux outer (B*S)	0,9851744
FMM (-dB flux/dt) (V)	-0,0985174
Length mean outer (m)	3,5168
Resistance outer (Ohm)	0,016956
Outer Current (A)	-5,8101816
Radial force (N) =I*L*Bz	-20,433247
Axial force (Nz)=I*L*Br	-14,303273

surface mid (m^2)	0,452376
B Flux mid (B*S)	0,452376
FMM (-dB flux/dt) (V)	-0,0452376
Length mean mid (m)	1,884
Resistance mid (Ohm)	0,0105975
mid Current (A)	-4,2687049
Radial force (N) =I*L*Bz	-8,04224
Axial force (Nz)=I*L*Br	-5,629568

Eddy Current PP1

Inputs

Bz max (T)	Br max (T)	Transient time (s	Al resistivity (Ohm*m)	r outer (m)	r mid (m)	r inner (m)	thickness (m)
1	0,7	10	0,0000027	0,7	0,42	0,18	0,002

surface outer (m^2)	0,9851744
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FMM (-dB flux/dt) (V)	-0,0985174
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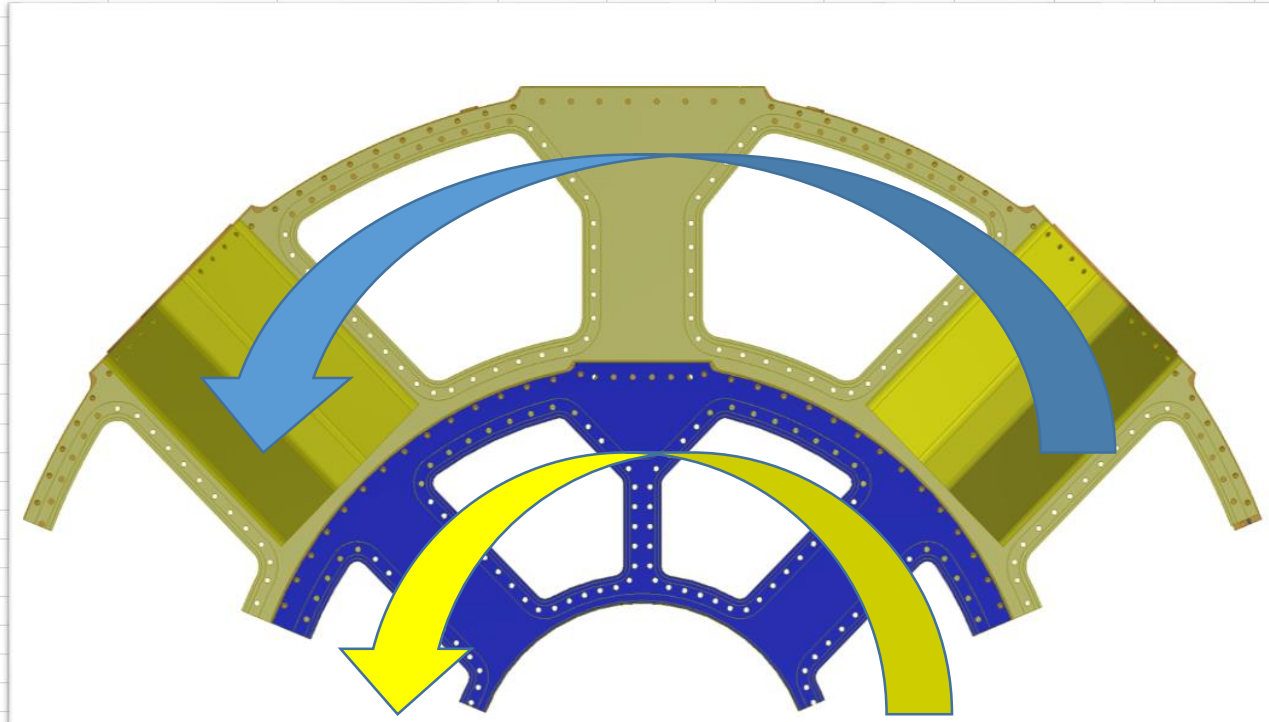
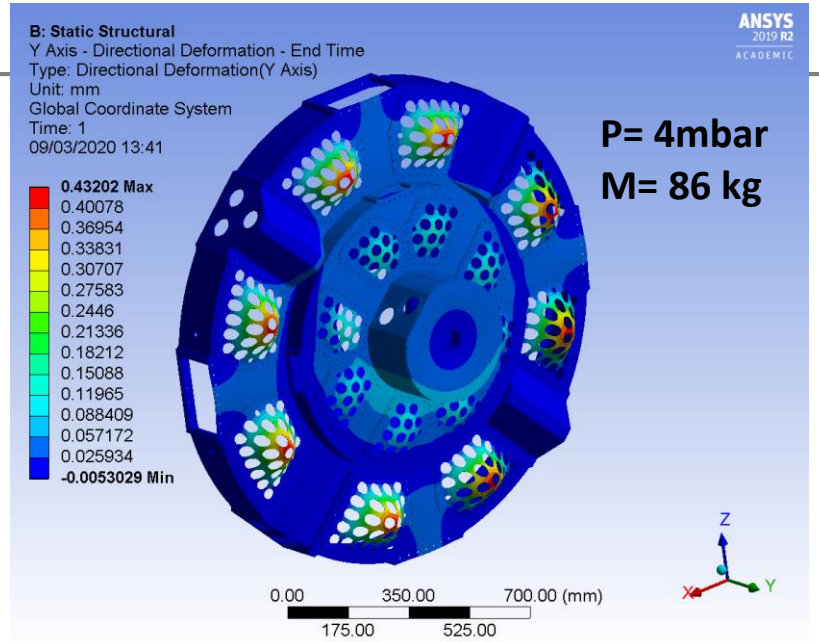


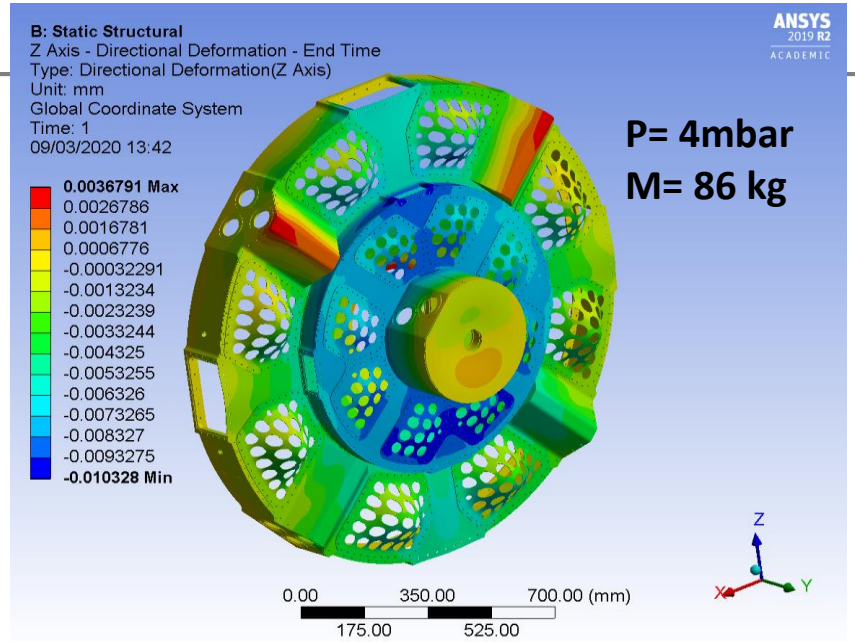
Outputs

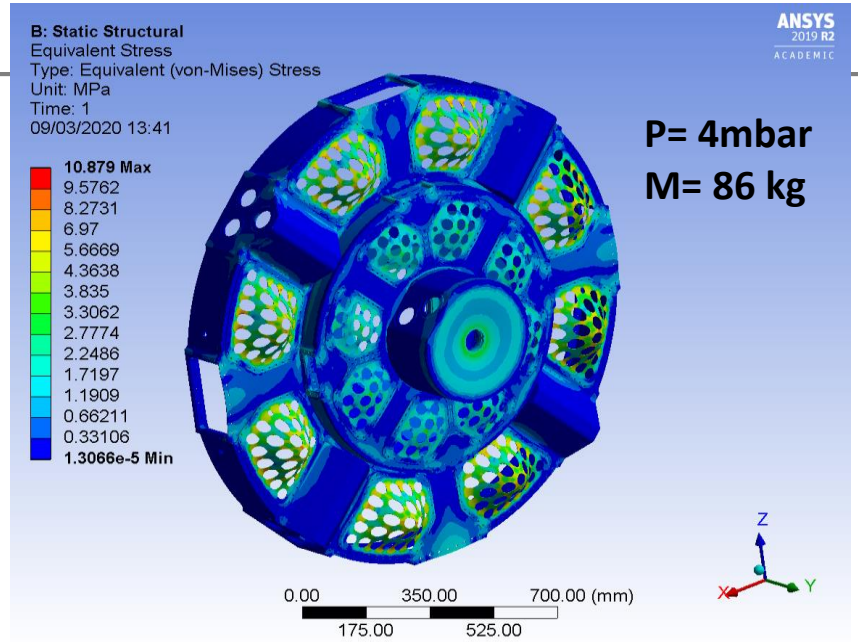
Total Axial Force (Fz) =	-19,93284077	N
Total radial force (Fr)=	-28,47548681	N

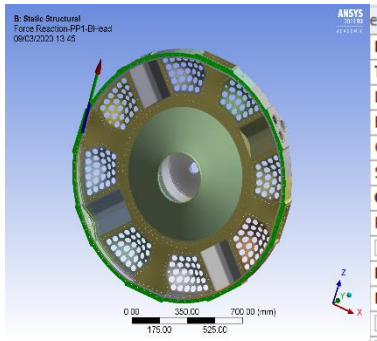
Total Axial Force (Fz) =	-19,93284077	N
Total radial force (Fr)=	-28,47548681	N

FEA SIMULATION





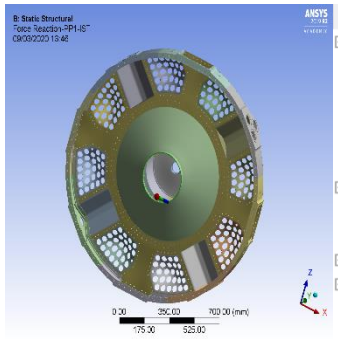




Details of "Force Reaction-PP1-BHead"

Definition	
Type	Force Reaction
Location Method	Boundary Condition
Boundary Condition	PP1-BHEAD
Orientation	Global Coordinate System
Suppressed	No
Options	
Result Selection	All
Display Time	End Time
Results	
Maximum Value Over Time	
X Axis	3.0412 N
Y Axis	-251.37 N
Z Axis	1011.8 N
Total	1042.6 N
Minimum Value Over Time	
X Axis	3.0412 N
Y Axis	-251.37 N
Z Axis	1011.8 N
Total	1042.6 N

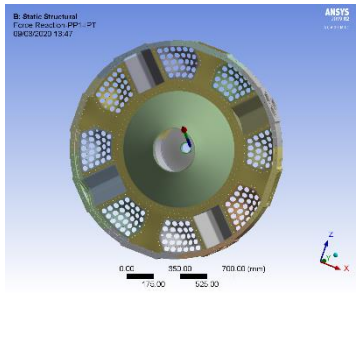
Bulkhead
Reaction force



Details of "Force Reaction-PP1-IST"

Definition	
Type	Force Reaction
Location Method	Boundary Condition
Boundary Condition	PP1-IST
Orientation	Global Coordinate System
Suppressed	No
Options	
Result Selection	All
Display Time	End Time
Results	
Maximum Value Over Time	
X Axis	-0.28377 N
Y Axis	-257.04 N
Z Axis	65.255 N
Total	265.19 N
Minimum Value Over Time	
X Axis	-0.28377 N
Y Axis	-257.04 N
Z Axis	65.255 N
Total	265.19 N
Information	

IST
Reaction force



Details of "Force Reaction-PP1-IPT"

Definition	
Type	Force Reaction
Location Method	Boundary Condition
Boundary Condition	PP1-IPT
Orientation	Global Coordinate System
Suppressed	No
Options	
Result Selection	All
Display Time	End Time
Results	
Maximum Value Over Time	
X Axis	0.77709 N
Y Axis	-94.004 N
Z Axis	32.094 N
Total	99.335 N
Minimum Value Over Time	
X Axis	0.77709 N
Y Axis	-94.004 N
Z Axis	32.094 N
Total	99.335 N

IPT
Reaction force

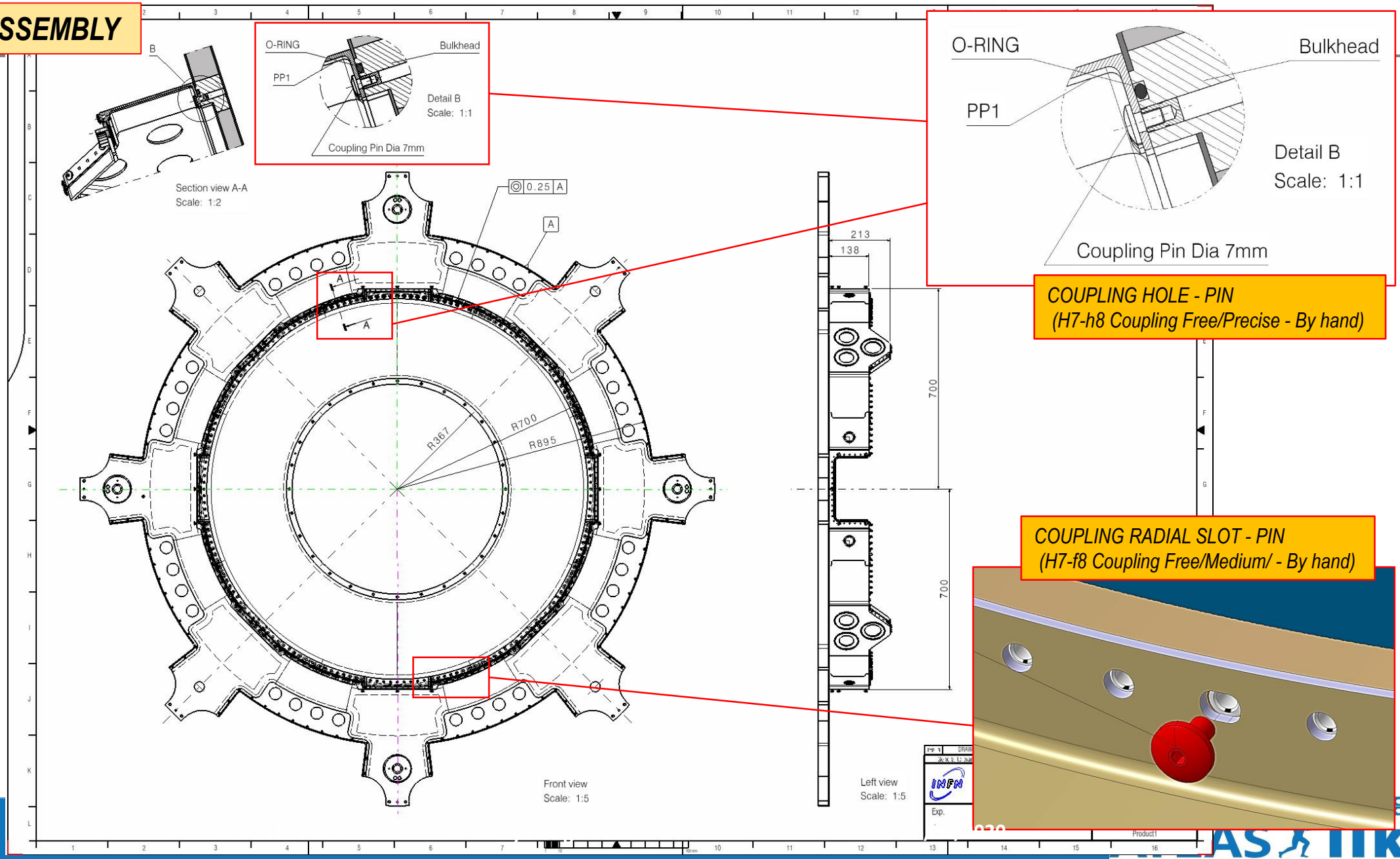
CONCLUSIONS

- MECHANICAL DESIGN IS COMPLIANT TO THE ENVELOPE, MASS BUDGET AND SERVICE REQUEST
- PP1 MOCKUP IS ONGOING TO VALIDATE THE MECHANICAL DESIGN AND PRODUCTION
- DATA CABLE FEEDTHROUGH MOCKUP ALREADY PRODUCED TO CHECK THE LEAK RATE AND INTEGRATION PROCEDURE
- FLANGED JOINTS MOCKUP ALREADY PRODUCED TO CHECK THE O-RING LEAK RATE
- SPECIAL EPDM O-RING SAMPLES FROM JAMES WALKER PROCURED TO TEST THE RADIATION HARDNESS AND LEAK RATE AFTER IRRADIATION
- EDDY CURRENT EFFECTS & FEA PERFORMED

BACKUP SLIDES

PP1-BULKHEAD INTERFACE

PP1 – BULKHEAD ASSEMBLY

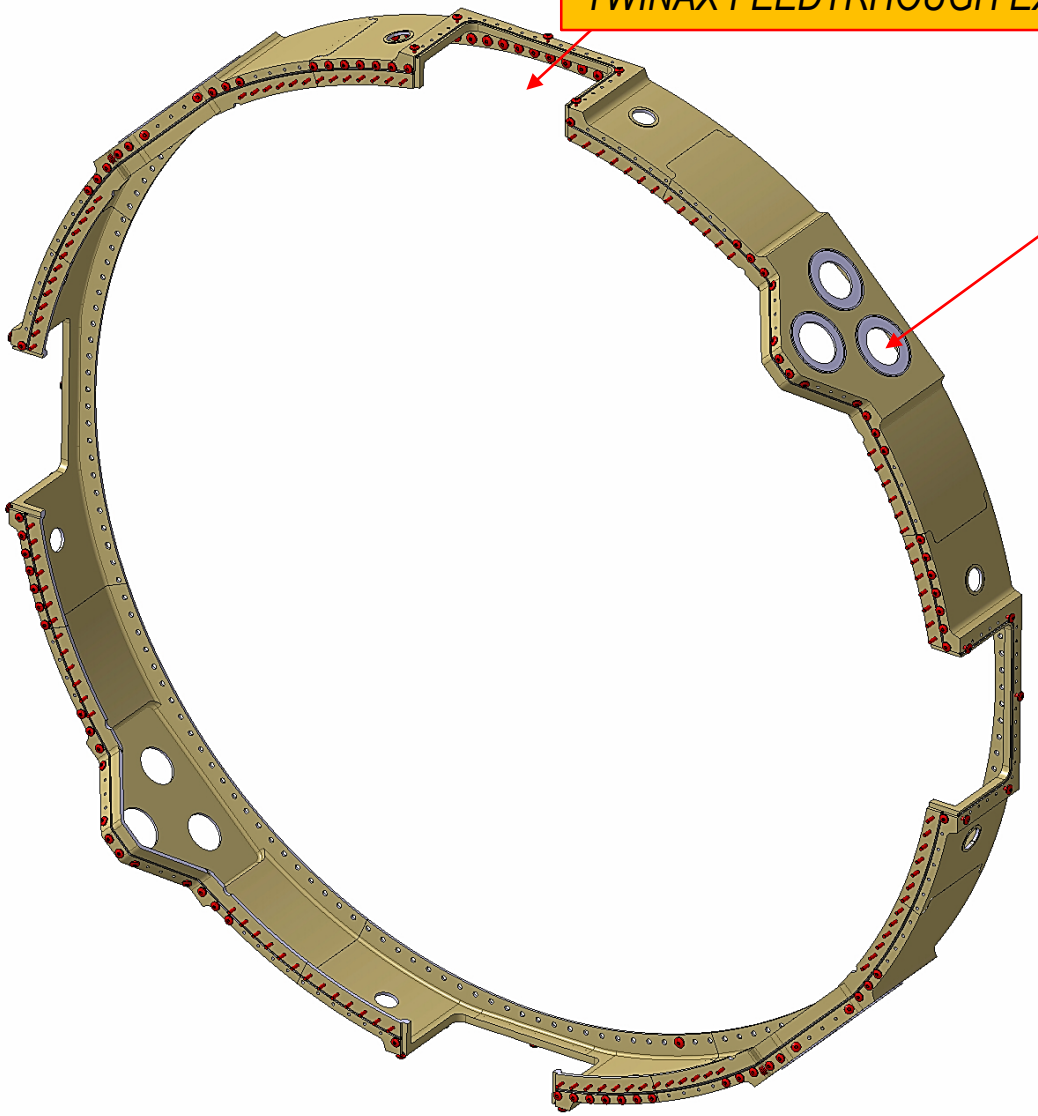


COUPLING HOLE - PIN
(H7-h8 Coupling Free/Precise - By hand)

COUPLING RADIAL SLOT - PIN
(H7-f8 Coupling Free/Medium/ - By hand)

PP1 DESIGN DETAILS 1

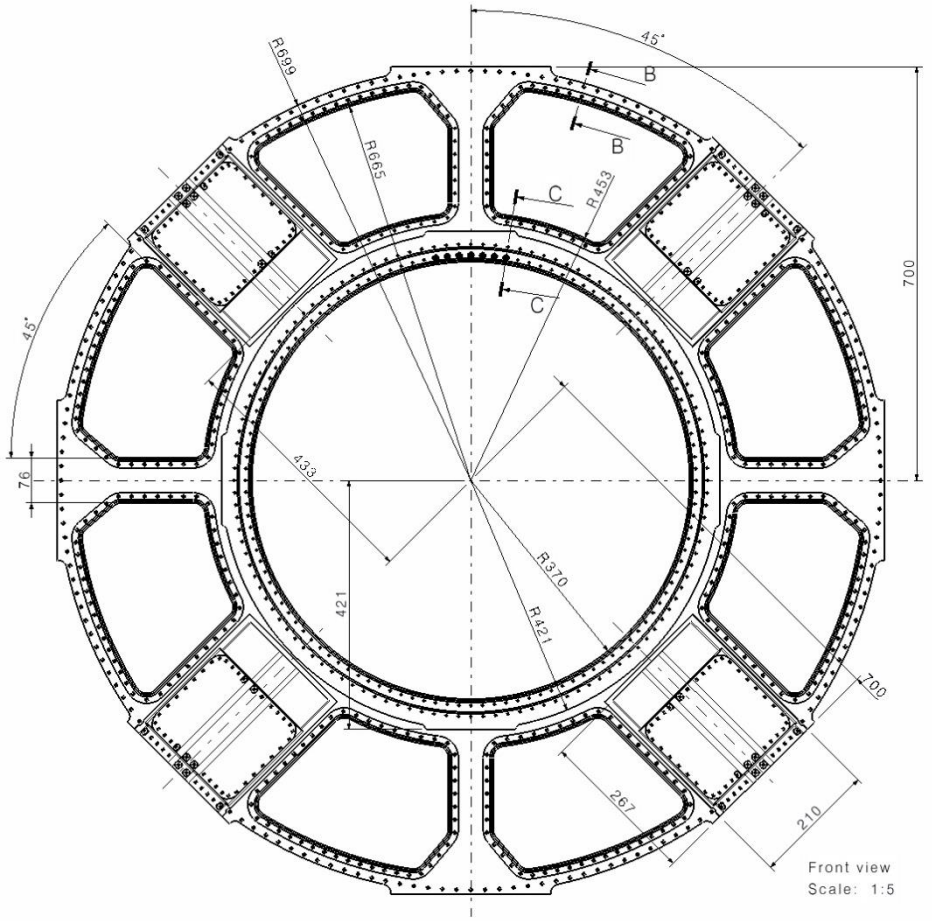
PP1 – OUTER FLANGE

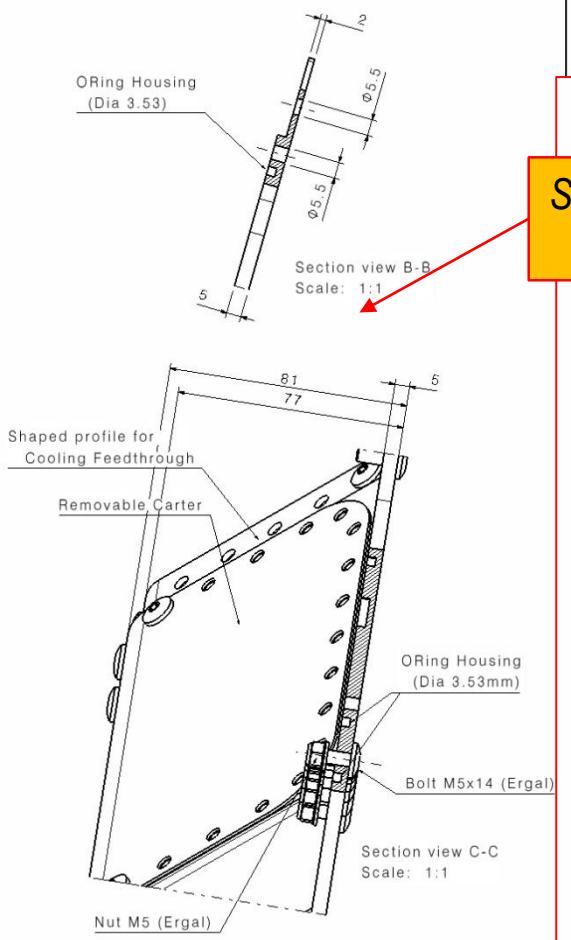


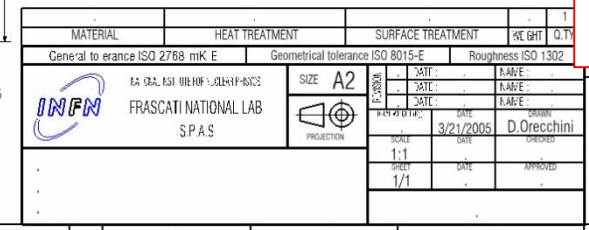
MATERIAL: Alloy 6082 Anticorodal
WEIGHT: 9Kg

PP1 DESIGN DETAILS 2

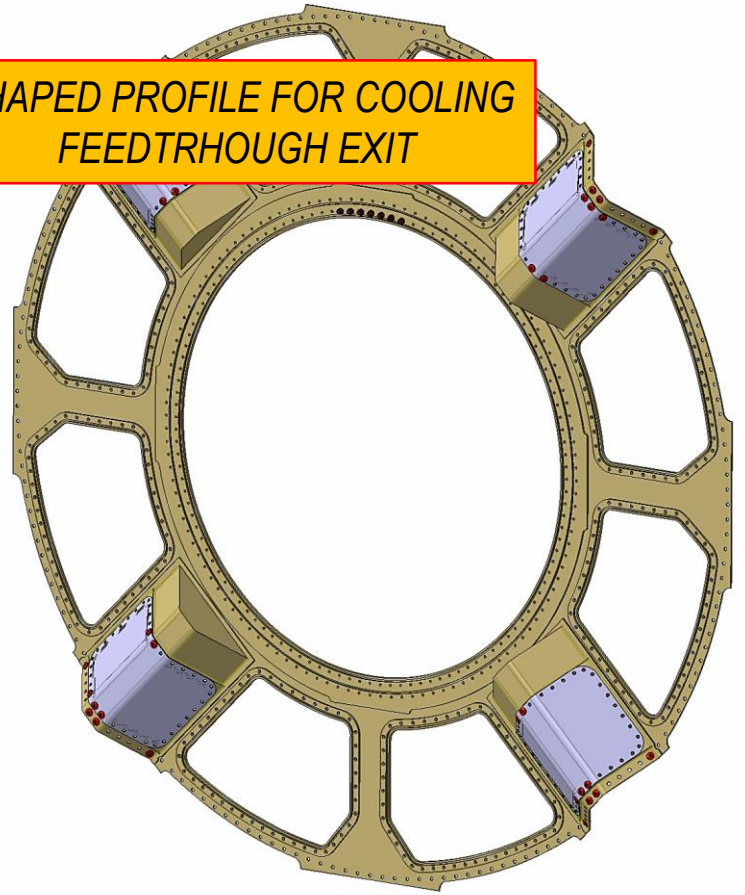
PP1 – OUTER FLANGE







SHAPED PROFILE FOR COOLING FEEDTRHOUGH EXIT

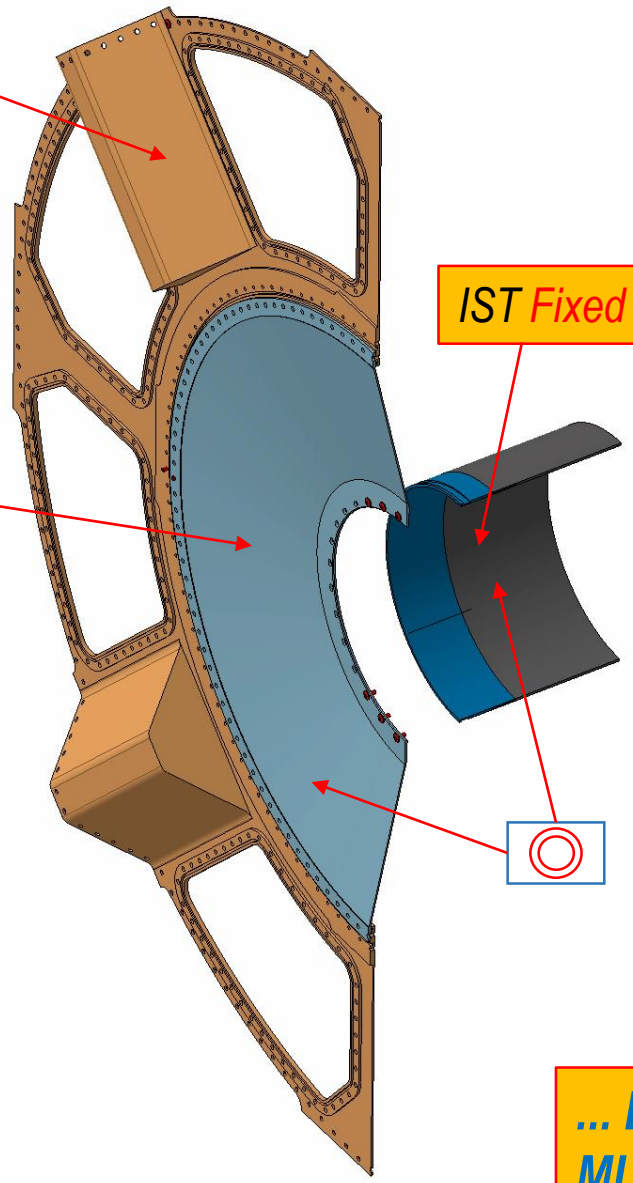


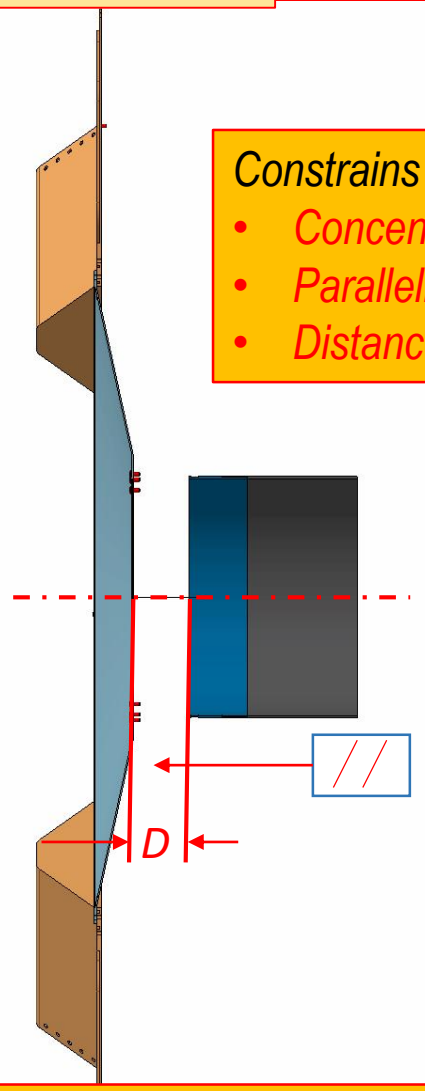
MATERIAL: Alloy 6082 Anticorodal
WEIGHT: 5,4Kg
(Made by Water Cutting & Milling Machining)

IST - PP1 INTERFACE CONSTRAINT ANALYSIS

PP1_Outer Wall
Fixed Part

CONE FLANGE
Rigid Part





Constrains between PP1 Outer Wall – Cone Flange

- Concentricity
- Parallelism
- Distance

AND MOREOVER

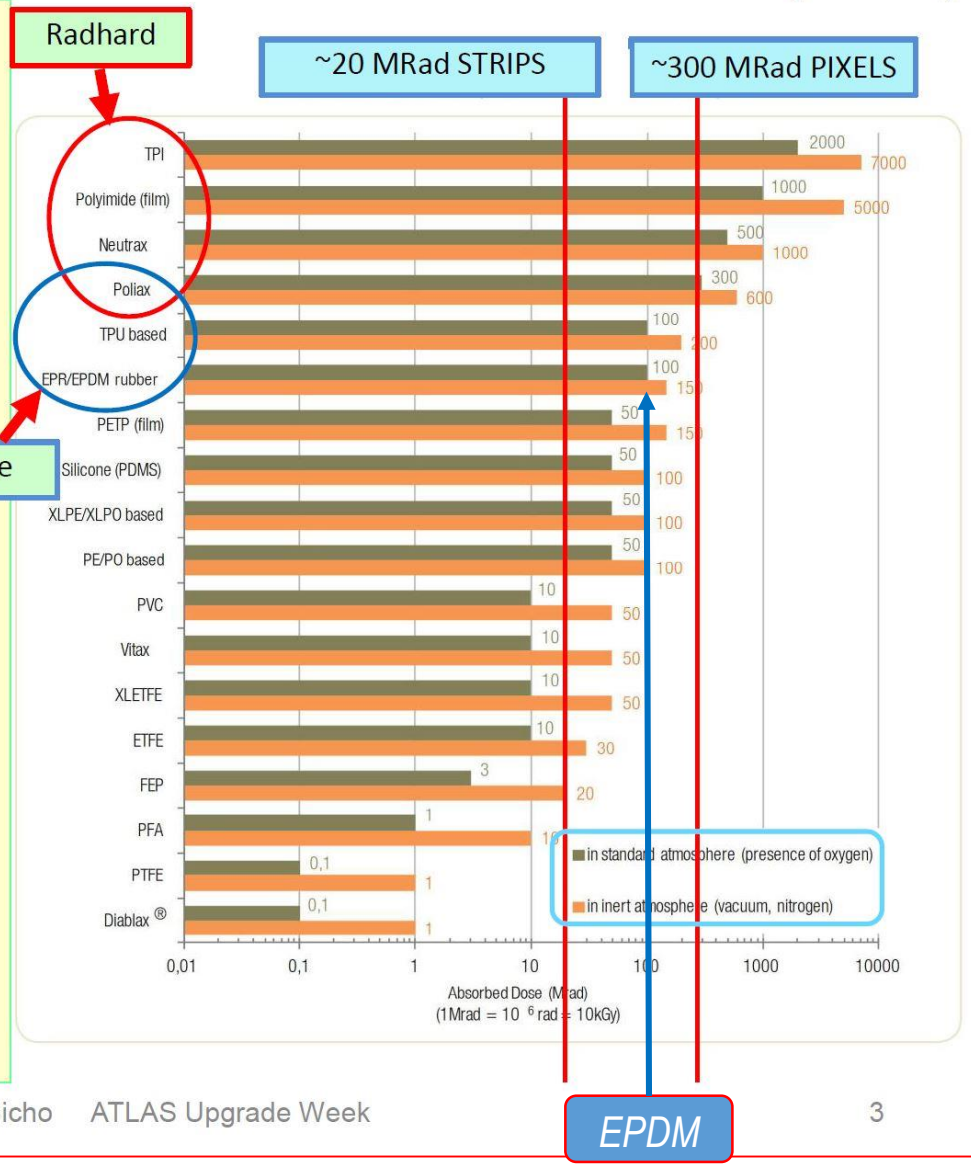
... DUE TO THE AVAILABLE SPACE THE COUPLING COMPONENTS MUST BE ASSEMBLED AND DISASSEMBLED IN SEQUENCE.

PP1 CHOICE OF GASKETS

Radiation resistance of different insulation materials (Axon)

- Radiation resistance of insulation materials significantly limits the choice. Basically only few materials can be considered:
- **TPI** (extruded polyimide)
- **Polyimide film** (kapton)
- Neutrax (PEEK based)-not recommended (brittle wire insulation).
- **Poliax** - already near the margin..
- Luckily all materials mentioned above are **LSZH** and flame retardant ☺ but are not very flexible ☹
- TPU (polyurethane) - Likely the only really flexible material..
- Probably we assume negligible amount of oxygen under ITK endplate thus higher values in the plot can be considered...

From Petr Slides

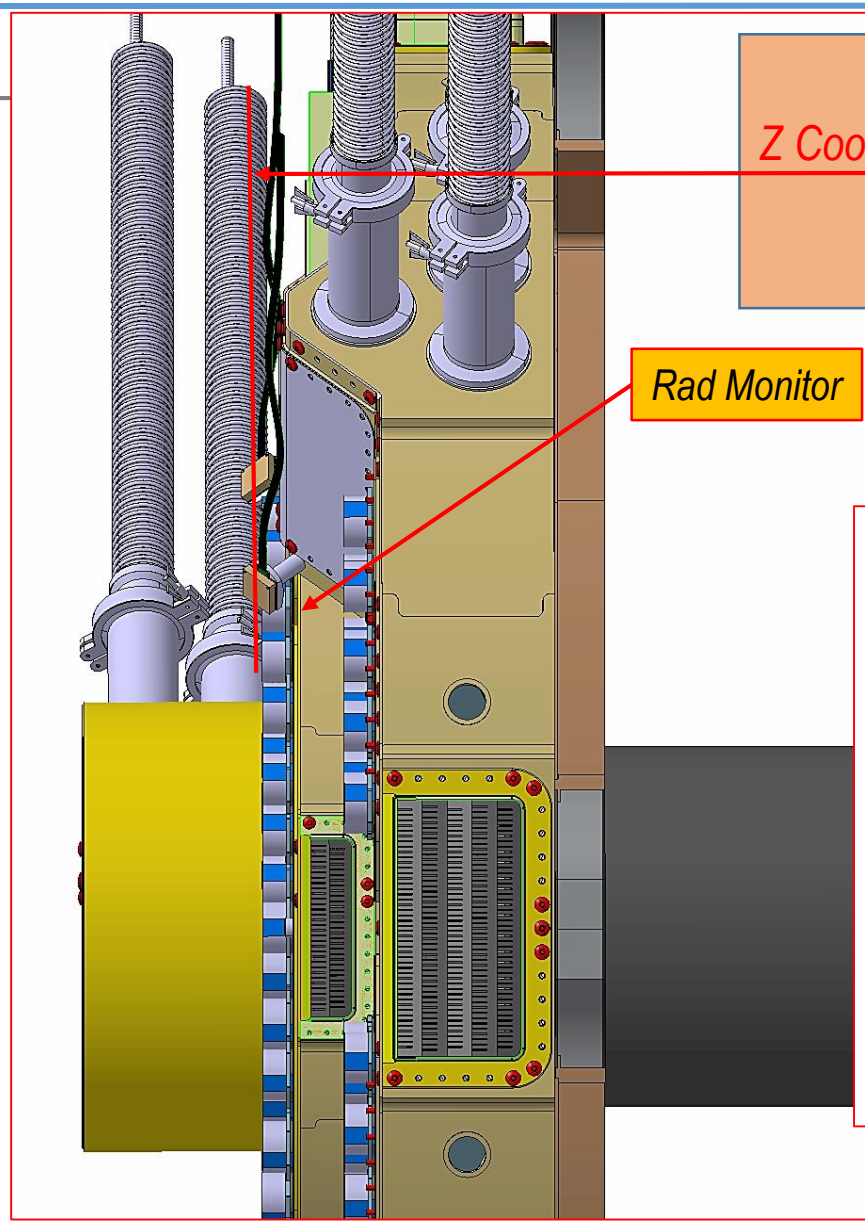


Carbon Fiber thermal expansion coefficient: Lenght m x λ x C ° (degrees of temperature increase)

Temperature from 20 ° C to 70 ° C for:

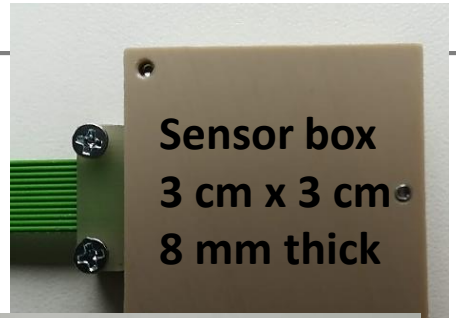
- *Carbon fiber T300: 0,74x10 ^ 6 / K (0,000074)*
- *Carbon Fiber M40: 1,23x 10 ^ 6 / K* (0,00000123)
- *- CFRP: 0,000050 (indicative 50 times less Aluminum 0,000023)*
- *- Tianium: 0,0000086*

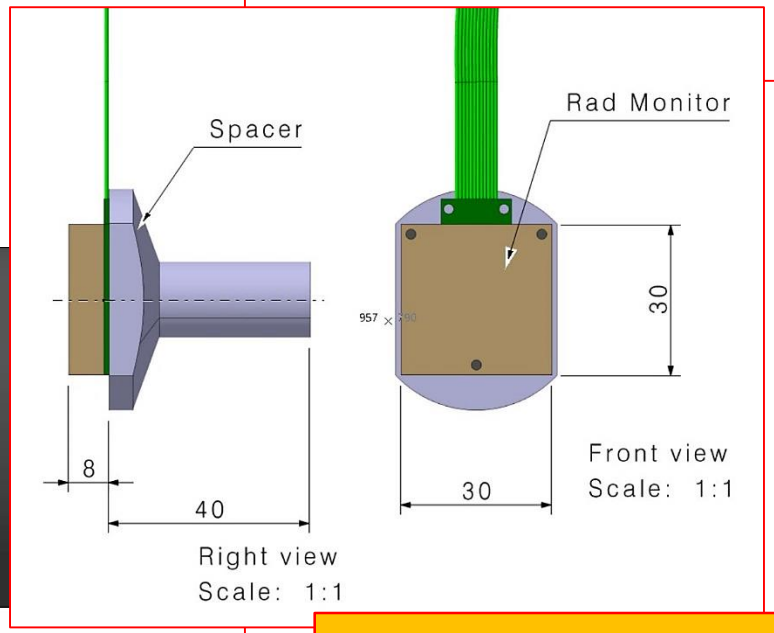
PP1-RAD MONITOR LOCATION

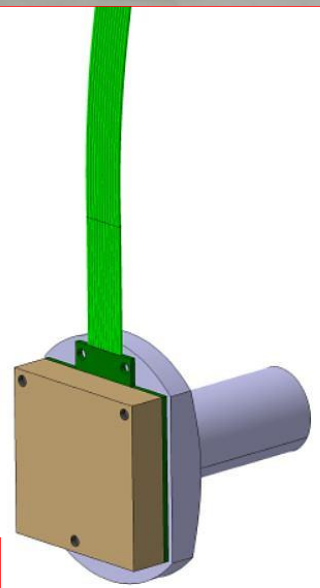


Z Coordinate 3258 mm *(with a spacer)*
(3200mm requested by Igor Mandic)

Rad Monitor







RAD MONITOR MODEL